



Create Particle Traces

INTRODUCTION

A particle trace represents the path a massless particle would take if released in a flow field. From an initial seed point (the *emitter*), a path is formed by integrating through the velocity field over time. The path is therefore everywhere parallel to the flow. Traces calculated in a steady-state flow field are called *streamlines*. For transient flow, the path is known as a *pathline*.

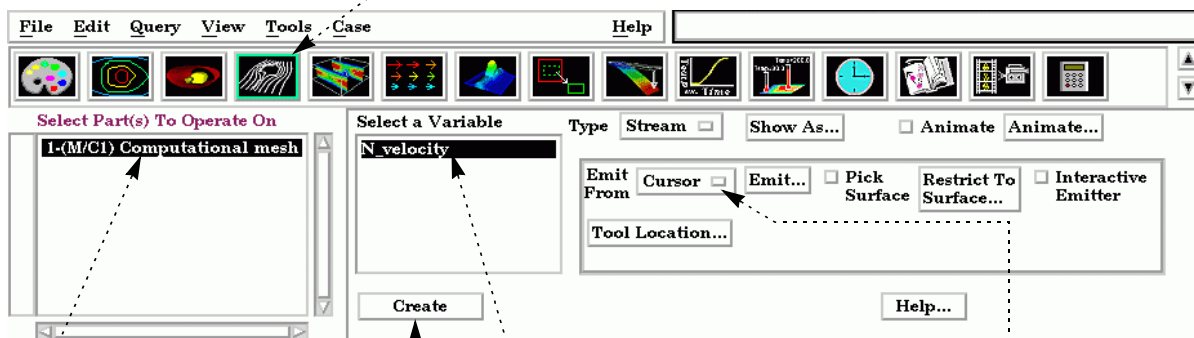
EnSight provides a great deal of control over emitter definition and trace appearance:

- Emitters can be defined using one of the built-in tools (Cursor, Line, or Plane) or by clicking on any surface in the Graphics Window. The nodes of an arbitrary part can also be used as an emitter.
- The streamline path can be generated in the positive, negative, or positive and negative time directions.
- Traces can be restricted to lie on any surface to search for flow topology and separation features.
- For transient cases, an emitter can have a delta time that controls the periodic release of additional particles into the dynamic flow.
- Emitters can be interactive: as you move the emitter with the mouse, the associated traces automatically recalculate and redisplay.
- Trace paths can be displayed as lines, ribbons, or as square tubes, where ribbon or tube twist follows the local flow rotation around the path.
- Particle traces can be easily **animated** to provide intuitive comprehension of the flow field. Complete control over all aspects of the animating tracers is provided, including length, speed, and release interval for multiple pulses.

BASIC OPERATION

To trace particles through a steady-state flow field:

2. Click the Particle Traces icon.....



1. Select the flow field mesh part(s) to trace through.

3. Select the vector variable to use.

4. Select the desired emitter.

5. If the emitter is a tool (**Cursor**, **Line**, **Plane**), position the tool at the desired emitter location. You can also click the Tool Location button to precisely position the tool. If the chosen emitter is Part, then enter the part number in the Part ID field and press return.

6. Click Create. The particle traces will be created from the desired emitter. Their maximum time duration is controlled via the Total Time Limit found under Emit...

How To ... Create Particle Traces



The following are the available Emit From options. Note that traces will only be generated for those emitter points that actually lie within an element of the selected flow field part(s).

Cursor	A single trace will be emitted from the Cursor tool.
Line	Multiple traces will be emitted from evenly spaced points along the Line tool. Enter the desired number of traces in the # Points field and press return.
Plane	Multiple traces will be emitted from evenly spaced points in a grid pattern over the Plane tool. Enter the desired number of traces in the X and Y direction (with respect to the Plane tool's axis) in the # Points X/Y fields and press return. The total number of traces will be the product of X and Y.
Part	One trace will be emitted from each node of the part (if the Density = 1.0, otherwise according to the density value the appropriate fraction of nodes will be used as emitters). Enter the number (from the Main Parts list) of the part you wish to use as an emitter.

The complete set of particle trace attributes can be edited in the Feature Detail Editor for Traces. However, some emitter attributes can be changed from the Particle Traces Quick Interaction area by clicking the Emit... button:

Click to set the trace direction: -----

- + : forwards in time (positive velocity direction) from the emission point(s)
- : backwards in time (negative velocity direction) from the emission point(s) towards the entering flow boundary
- +/- : both forwards and backwards

Toggle on to have start time be the current time, otherwise specify the start time. -----

- Set the total amount of time a trace will last (it may terminate for other reasons as well).
- Solution time at which to begin pathline trace (pathlines only).
- Delta emission time for pathlines. If not zero, a new set of traces will be emitted at S, S+D, S+2D, etc. into the changing flow field (where S is the Start time and D is the delta value). Used to create *streaklines* or *smoke traces*. Animated streaklines are one of the most powerful methods for visualizing transient flow.

Display Traces as Ribbons or Square Tubes

Particle paths can be displayed as lines, ribbons, or square tubes, where ribbon or tube twist follows the local flow rotation. To enable ribbon or square tube display:

1. Double-click the desired particle trace part in the Main Parts list (to open the Quick Interaction area for the trace part).
2. Click Show As... to open the Trace Show As Attributes dialog.
3. Set Show As to Ribbon or Square Tubes.
4. If desired, change the default ribbon or square tube width and press return.
5. Click Close.

Animate Particles

Any type of particle trace can be animated. See [How To Animate Particle Traces](#) for more information.



Pick a Surface to Trace a Particle

Rather than emit from a tool or a part, you can also interactively pick points on a surface in the Graphics Window to define emitter locations. To do this:

1. Execute steps 1-3 as described above.
2. Click the Pick Surface toggle.
3. Click Create.
4. Move the mouse into the Graphics Window and click the left mouse button when the cursor is over the desired location. The clicked point must be found within some element of the selected flow field mesh part to result in a trace.
5. You can click to create as many point emitters as you like. When done, move the mouse out of the Graphics Window.
6. Toggle off the Pick Surface button.

Note that you can also specify a rake (line) or net (plane) emitter by picking on a surface. Just set the emitter to Line or Plane prior to clicking Create. Then follow in the instructions in the pop-up window.

Interactive Particle Tracing

If a particle trace was created from one of the tool emitters (Cursor, Line, or Plane) and the trace is not a pathline trace, the emitter can be made interactive. When interactive, the tool that created the particle trace part can be moved with the mouse. As the tool is moved, new particle traces are automatically recalculated and redisplayed. To trace interactively:

1. Either create a particle trace part as described above (based on a tool) or double-click an existing particle trace part to open the Quick Interaction area for that part.
2. Toggle on Interactive Emitter. If the tool that originally defined the emitter is not visible, it will be turned on by this operation.
3. Move the mouse into the Graphics Window and manipulate the tool as desired. See the article on the applicable tool for information on tool manipulation ([Cursor](#), [Line](#), or [Plane](#)).
4. When done, toggle off Interactive Emitter.



Trace Surface-Restricted Particles

EnSight can trace particles such that they are constrained to lie on a (not necessarily planar) 2D surface – even if the velocity is zero at the surface. The trace is calculated by projecting a short distance off the surface into the 3D flow field and using the velocity value found there. Both the projection distance (variable offset) and a display offset are user definable.

Surface-restricted trace emitters are defined by mouse action in the Graphics Window. When you click and drag over the desired surface, the emitter is defined by projecting the mouse path onto the surface. To trace surface-restricted particle traces:

1. Select **Edit > Part Feature Detail Editors > Particle Traces...** to open the Feature Detail Editor (Traces) dialog.

2. Select the desired surface part(s) in the Main Parts list. This should be the surface you wish to trace on.

3. Set the desired vector variable to use for tracing.

4. Select the desired emitter type (Cursor, Line, or Plane). Note that the applicable tool will not actually be used in this operation.

5. Set other desired settings (e.g. trace direction or time limit).

6. Toggle on the Surface Restricted button. Note that all subsequent tracing will be assumed to be surface restricted until this is toggled off.

7. If desired, adjust the Variable and Display Offsets. (You can also change the Display Offset for a previously created trace without having to recalculate it.)

8. If the Emit From is set to Line or Plane, enter the desired number of points (Line) or X and Y points (Plane).

9. Click the Create button at the bottom of the dialog (not shown here).

Creation Attributes

Variable

X Y Z

Type

Show As Ribbon Width

Emitter Information

Emit From # Points

☐ Interactive Emitter

Direction Total Time Limit

☐ Emit At Current Time

Emission Time Start Time Delta

☒ Surface Restrict ☒ Pick Surface

Variable Offset Display Offset

10. Move the mouse pointer into the Graphics Window and:

for a Cursor emitter: click the left mouse button on the desired location.

for a Line emitter: click and hold the left mouse button on one endpoint of the desired line. Drag to the other endpoint (a white line will provide feedback).

for a Plane emitter: click and hold the left mouse button on one corner of the desired region. Drag to the opposite corner (a white rectangle will provide feedback).

11. You can continue to specify emitters of the selected type as long as the mouse pointer remains in the Graphics Window. When the pointer exits the window, the trace part will be created.

12. When done, toggle off Surface Restricted.



ADVANCED USAGE

Trace Pathlines

EnSight provides complete control over transient particle tracing. Both the start time and the stop time can be specified. In addition, you can specify a delta value for an emitter that will cause additional particles to be emitted into the flow at regular intervals. This type of pathline is also called a *streakline* or *smoke trace*.

You create a pathline trace by setting the Type to Path (rather than Stream) prior to clicking Create. By default, the pathlines will start at the first time step of your simulation and terminate at the last step (unless stopped earlier). You can change these defaults with the Emission Detail Attributes dialog as described above (click Emit... to open).

Edit Emitter Attributes

Although the Particle Trace Quick Interaction area provides most tracing controls, the Feature Detail Editor for Traces provides complete control over all creation attributes. To use the editor:

1. Select **Edit > Part Feature Detail Editors > Particle Traces...** to open the **Feature Detail Editor (Traces)** dialog.
2. Select the desired particle trace part in the part list at the top of the dialog.

Creation Attributes

- Variable:** (Set the desired flow field variable)
- X:** **Y:** **Z:** (Set the fraction of each component of the vector variable to use in the trace calculation)
- Type:** (Trace type)
- Show As:** **Ribbon Width:** (Line or ribbon display)

Emitter Information

- Emitters:** (List of the emitters belonging to the selected trace part)
- Emit From:** (Emission tool for currently selected emitter)
- Interactive Emitter:** ☒ (Set interactive emitter)
- Add Emit:** (Add Emit: add a new emitter to the selected part based on the current attributes)
- Delete Emit:** (Delete Emit: delete the selected emitter)
- Direction:** (Set emitter direction, total time)
- Total Time Limit:** (Set to emit at current time, or set emission time)
- Emit At Current Time:** ☐ (Set to emit at current time, or set emission time)
- Emission Time Start:** **Time Delta:** (Set emission delta)
- Surface Restrict:** ☒ **Pick Surface:** ☐ (Toggle on surface picking for emitter definition)
- Variable Offset:** **Display Offset:** (Toggle on Surface Restricted tracing)

Time Step Determination

Massed Particle



Massed Particle Traces

EnSight also provides massed particle traces via the Feature Detail Editor for Traces.

1. Select **Edit > Part Feature Detail Editors > Particle Traces...** to open the Feature Detail Editor (Traces) dialog.

2. Select the desired the particle trace part in the part list at the top of the dialog.

3. Click the Massed Particle turn-down to reveal the massed particle parameters.

4. Modify the massed particle parameters according to your dataset. For instance, to compute only the drag force term in the momentum balance equation, toggle off the Gravity force term.

5. Toggle on Massed Particles.

The selected particle trace part will update to a massed particle trace(s) taking into consideration the drag force term parameters only.

Massed Particle

☒ Massed Particles

Force Terms ☐ Drag ☒ Gravity ☐ Pressure

Particle Diameter

Particle Density

Initial Velocity

☐ Use Fluid

X Y Z

Gravity Vector

X Y Z

Fluid Density

Or

Fluid Dynamic Viscosity

Or

Pressure Gradient

Drag Coefficient Function

OTHER NOTES

Particle trace calculation can be expensive for large or transient datasets and/or a large number of particles. Be careful when you initiate a trace operation – there is currently no way to abort it. If you are calculating pathlines, you should specify as many particles as possible at one time. Much of the pathline execution time is in reading the transient data from disk and this operation has to be performed regardless of how many traces were specified.

The EnSight particle trace algorithm integrates the vector flow field over time using a 4th-order Runge-Kutta method with a time varying integration step. Several of the integration parameters can be changed by the user. See [Particle Trace Create/Update](#) in the User Manual for more information.

Although EnSight only traces massless particles, if you have trace data for other types of particles (e.g. for multi-phase flow simulations) you can use the [discrete/measured data](#) facility to load the particle path positions and animate them over time.

SEE ALSO

[How To Animate Particle Traces](#)

User Manual: [Particle Trace Create/Update](#)